Gamma-Ray Tracking with Large Area Planar Germanium Detectors (HpGeDSSD's)

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In collaboration with

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Current Areas of Detector R & D

● **Increasing detector Efficiency through enhancing wafer size:**

The ANL "Mark3" detector is the largest functioning germanium planar detector made to date, with a 92 x 92 x 20mm hyperpure wafer.

● **Improving detector Energy Resolution:**

To improve signal sensitivity and signal/noise. The "Mark4" detector with cold FET preamplifiers will have <1keV resolution at 122keV.
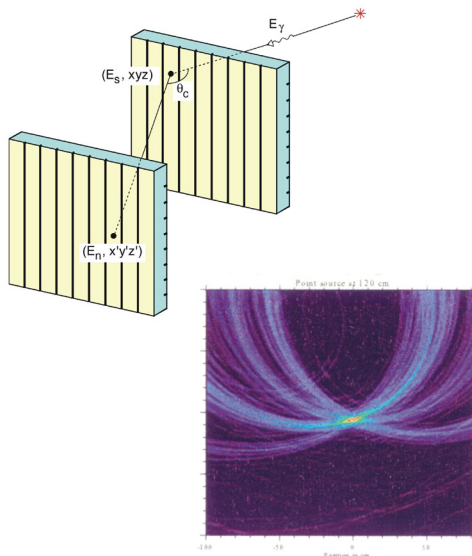
● **Two different levels of tracking:**

Through use of pixel location and with conventional electronics NOW Directional sensitivity $\theta \sim \pm 8$ degrees

Through digital pulse processing of neighbor-strip "image charges" in R & D phase. Directional sensitivity dominated by Fermi motion of electrons. $\theta < \pm 2$ degrees.
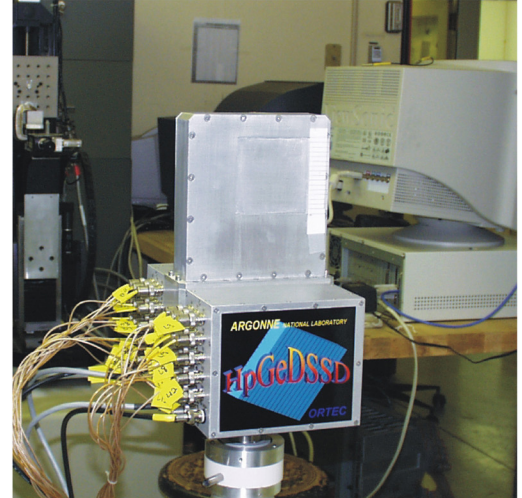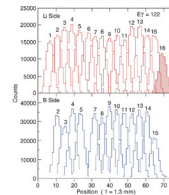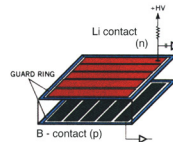
Compton Camera

Compton Circles
Two HpGeDSSD's Together Can Be Used to Pinpoint Sources of Radiation
(Naval Research Lab.)

Each detected photon with a 2-wafer interaction and $E = E_s + E_n$ allows $\cos\theta_c$ to be calculated, and a "Compton Circle" inferred.

Three photons give three circles, with a unique intercept at the source position.

Subsequent events improve signal/noise and average over "Fermi motion" of struck electrons, improving precision of direction-finding.

Has been successfully deployed using 2mm pitch "pixel" detectors (NRL).

Digital Pulse Processing of image charges will allow improved imaging.

Technique works best for relatively high energy photons (~1MeV) where signals are large and Compton scattering is the dominant interaction process.

Details of this and related work on HpDSSDs at NRL are published on their website at http://gamma.nrl.navy.mil/detector/papers.html

Digital Pulse Processing for Depth and Lateral Position Interpolation

● **Lateral Profiling from "Neighbor Strip" Transients (ANL).**

The primary photon interactions create electron and "hole" charges which drift towards the collection electrodes. The moving charges induce transients on neighboring strips. These transients are sensitive to the position of the interaction beneath the strip; for example a central interaction induces equal pulses on left and right neighbors. The polarity of these pulses gives further information on the depth of the interaction.
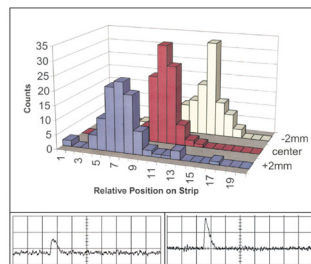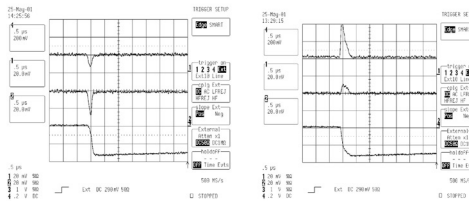

● **Depth Profiling from Charge-Pulse Risetime (NRL).**

The moving charges induce transients that modify the charge pulse risetime according to the drift distance, allowing the depth of the interaction to be measured.

Current Applications of HpGeDSSDs

● **Computer Assisted Tomography (CAT) Imaging**

(SBIR) project to search for life on Mars, funded by NASA and in Collaboration between ANL and Bio-Imaging Research Inc. Of Lincolnshire IL, Spokesman Dr. D. Nisius). Measured with the ANL "Mark 3" detector with 5mm strip-pitch. Image is of a 5mm x 7mm quartz disc with 1mm inserts of parafin and graphite, using 24keV and 88keV photons from a 15mCi Cd source. Rotation of the sample gives a 3-D Image with Z-identification.
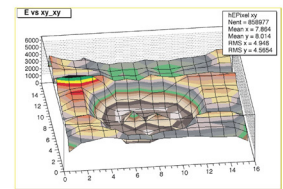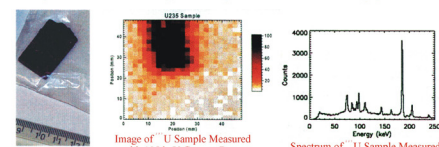

● **High Resolution Absorption Mapping**

Absorption image of a garage door key made with 60keV gamma rays, using one of the NRL 50mm x 50mm x 10mm HpGeDSSDs with 2mm pitch.
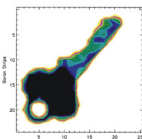
● **High Resolution Emission Maps**

A 185keV gamma ray image of a U sample made using a multi-pinhole mask and using a NRL HpGeDSSD with 2mm strip-pitch.

Photograph of U Sample Dimensions are ~ 1.5 cm x 3 cm (Naval Research Lab.)

Image of U Sample Measured with 185 keV Gamma Rays. Pixels are 2 x 2 cm.

Spectrum of U Sample Measured While Collecting the Image